Productivity of Selected Indiana Soils[1]

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Abstract

Corn (*Zea mays* L.) grain yields of 10 soils from five high yielding farms were compared for 6 years. One swell soil (Crosby, Reesville, or Iva series) was compared with an adjacent swale soil (Brookston, Ragsdale, or Zipp series) in the same field on each high yielding farm. Both the range in yields and the coefficients of variation of yields tended to be higher and the mean yields tended to be lower for the swell soils. In clay pot trials conducted outside in June, the number of corn plants that emerged from one Crosby silt loam was significantly less than from each of six other soils and another Crosby silt loam from the high yielding farms. Both dry weight and height of plant tops from high ground soils tended to be lower than those from swale soils in these pot trials. In a comparison of two sources of corn grain yield data, three soil series and 13 yields from each source of data were used. On the same soil series, grain yields from objective yield surveys of the Statistical Reporting Service tended to be lower and more variable than those from the high yielding farms.

Introduction

In 1957 Rust and Odell (6) reported their methods used in evaluating productivity of Illinois soils. Multiple curvilinear regression analyses were used to relate input data to yield in relation to soil types on approximately 20,000 fields. They found that approximately 100 to 200 fields were needed to make reasonably accurate estimates of crop yields for a soil type or an association of two closely related soils under the conditions observed. In 1958, Odell (3) reported how he used soil survey information, experimental plot data, and farm production records to estimate yields by soil types. Recently, a small amount of information on yields by soil type in Indiana was published by Barber (1) and by Stivers (8). In 1972, Purdue (2) made estimates of crop yields of Indiana soil series and management types by management productivity groups. Some similar information published by Odell and Oschwald (4) is applicable in Indiana. Even with all of these publications, more information from field trials about soil type productivity in Indiana is needed.

The purposes of this paper are: 1) to report corn (*Zea mays* L.) yield data from field and pot experiments on selected soil types, and 2) to compare corn yield data from the objective yield surveys of the Statistical Reporting Service with data from high yielding farms on selected soil series or types.

Methods and Procedure

Field Trials on High Yielding Fields

Corn grain yields on 10 soils from five high yielding farms in central and north central Indiana were compared over a 6-year period.

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Four years of data on fertilization, cultural practices, selected chemical properties and methods of yield sampling of the soils on these high yielding farms were previously presented by Stivers (8). Fertilization, cultural practices, and methods of yield sampling were approximately the same during the last 2 years of the experiment, 1971 and 1972, as in the first four, 1967-1970. Yields are reported on the basis of 15.5% moisture in the grain.

The 10 soils included three soil series located on ridges or swells and three soil series located in swales or slightly depressed areas. The series and 7th Approximation classification of the swell soils are: 1) Crosby, fine, Aeric Ochraqualf; 2) Reesville, fine silty, Aeric Ochraqualf; and 3) Iva, fine silty, Aeric Ochraqualf. The same classification of the swale soils is: 1) Brookston, fine loamy, Typic Argiaquoll; 2) Ragsdale, fine silty, Typic Argiaquoll; and 3) Zipp, fine, Typic Haplaquept. All of the 10 soils except the two on the McKowen Farm were classified and described in the field by D. P. Franzmeier and A. L. Zachary. They also classified all of the above soils as mixed mesic.

Slope and erosion were not important variables among swell soils. Harvest areas were taken from the top of nearly flat parts of the ridges or swells where slope was less than 2%. Variations within soils are within the variations accepted for the named series.

One swell soil was compared with an adjacent swale soil in the same field on high-yielding farms. Adjacent swell and swale soils always received the same chemical and cultural treatments because the same rows were used in both soil areas. As previously explained (8), five sublocations were harvested and averaged to obtain the yield of one soil type in one year. Since the Neyhouse Farm did not cooperate in 1972, these two yields were not obtained. The method of missing values of Snedecor and Cochran (7) was used to supply two substitute values so that one analysis of variance could be used for all years and all soils. The analysis of variance used was that suggested by W. E. Nyquist. Sources of variation and their accompanying degrees of freedom were: 1) years, 5; 2) farms, 4; 3) years $\times$ farms, 20; 4) soils within farms, 5; and 5) years $\times$ soils within farms, 23.

Pot Trials of High Yielding Soils

Corn was grown outside in pots in June 1973 on the eight soils from the four high yielding farms that completed the field trials in 1972. Four fertilizer treatments were used on each of the eight soils. Fertilizers were applied on the basis of a weight of 2,000,000 lbs/acre (2,240,000 kg/ha) for a plow furrow depth (6 inches or 15 cm) of soil. The fertilizer treatments were 0-0-0, 0-87-167, 200-87-167, and 400-87-167 in lbs/A (0-0-0, 0-97-187, 224-97-187, and 448-97-187 in kg/ha) of nitrogen (N), phosphorus (P), and potassium (K). Fertilizers were mixed uniformly with the soil in each treatment prior to filling the pots and planting. Three replications of all treatments (eight soils and four fertilizers) were used in a completely randomized design. Eight seeds of Beck's 80X hybrid seed corn were planted per pot on June 8, 1973. The 2.20 lb (1.00 kg) of soil in each pot was completely saturated with tap water, and any excess was allowed to drain. The pots and contents were weighed and then placed on boards between two ranges of greenhouses in full sunlight near the Life Science Building, West Lafayette, Indiana.

On June 14, counts of emerged seedlings were made. Six additional seeds per pot were then planted in each of 24 pots having less than eight plants. On June 18, all pots were thinned to six plants per pot. Later as seedlings emerged all plants over six per pot were removed.

Water was applied by rainfall and by hand sprinkler hose daily or more often as needed. Twice during the experiment all pots were weighed. Water was added to bring total pot weights up to 80% of soil saturation as determined from previous weights.

Tops of corn plants were harvested July 1, dried at 140°F (60° C), and weighed.

Data of High Yielding Fields and Statistical Reporting Service Compared

Half of these corn yield data are from the Department of Agricultural Statistics and the U. S. Department of Agriculture's Statistical Reporting Service cooperating at Purdue University, Earl L. Park, Agricultural Statistician in charge. Corn yields were obtained by objective yield surveys on cooperating farms in randomly picked segments of land. Each segment usually contained two or three farms. Names of farmers were not known.

In the objective yield surveys two areas to be subsampled were picked by random methods in each corn field in which yields were determined. Each subsample was 15 feet long and 2 rows wide. Stalks and ears were counted, and sample ears were sent to the State Statistical Reporting Service laboratory for weight of grain, grain moisture determinations, and yield calculations.

Aerial photographs containing the cornfields harvested in the objective yield surveys were matched with soil survey maps made available by Donald P. Franzmeier, Agronomy Department, Purdue University. Where there were two different soil types in the two subsamples in the same field the subsample data were not used in this report.

The other half of the corn yield data by soil types came from selected high yielding farms previously mentioned. For the comparison with the Statistical Reporting Service data single subsample values, rather than the average of five subsample values reported in Table 1, were used. Prior to running analyses of variance, F tests of significance, standard error of the mean difference, and t tests, Bartlett's test of homogeneity of variance was used to compare both sets of data. Pearson and Hartley's (5) tables were used to interpret the Chi-square value obtained.

Results and Discussion

Field Trials on High Yielding Fields

The highly significant (1% level) interactions between years and farms as measured by mean corn grain yields can be seen in Table 1. For example, corn grain yields on the Franklin Farm were relatively higher, in comparison with those of the other farms, in 1971, with 186 bu/acre (11,666 kg/ha) while in other years they were relatively lower. Since the total July and August rainfall of 4.58 inches (116.3 mm) in 1971 was less than normal, sufficient rainfall was not the explanation for the high yields on the Franklin Farm.

The range in corn grain yields was greater on the swell soils (Crosby, Reesville, and Iva) than on the swale soils (Brookston, Ragsdale, and Zipp) when calculated according to the following equation:

$$\frac{\text{Highest yield Soil A} - \text{Lowest yield Soil A}}{\text{Highest yield, Soil A}} \times 100 = \begin{array}{c}\text{\% variation in}\\ \text{range of grain}\\ \text{yield}\end{array}$$

On the five swell soils variation in range of grain yields was from 27.7% to 41.9% with a mean of 34.1%; on the swale soils the variation in range was from 13.5% to 31.6% with a mean of 24.5%. Coefficients of variation were also greater on swell soils than on swale soils in four out of five comparisons in Table 1.

Average corn grain yields of the swell soils, 148 bu/acre (9,280 kg/ha), were 10 bu/acre (627 kg/ha) lower than those of the swale soils, 158 bu/acre (9,910 kg/ha). As shown by the larger "t" value in Table 1, the largest difference between average yields of swell and swale soils was between Crosby silt loam and Brookston silt loam on the McKowen Farm. This difference was 31 bu/acre (1,944 kg/ha). Even though the differences were much smaller in the other comparisons, the same trend was evident on the other high yielding farms. There were no meaningful differences among farms in corn grain yields.

Insufficient rainfall in 1967 in July and August on the Franklin Farm, 1.24 inches (31.5 mm), and on the McKowen Farm 2.32 inches (58.9 mm) appeared to be the cause for the low yields on the Crosby silt loam on these two farms (Table 1). Field observations indicated that there was much more leaf rolling on the Crosby than on the Brookston and/or Ragsdale soils in dry weather. Too much rainfall, 18.9 inches (480.0 mm) as well as detasseling operations and damage to the plants probably contributed to relatively lower yields on the Neyhouse Farm in 1971.

Pot Trials of High Yielding Soils

The number of corn plants that emerged from planted seed in Crosby silt loam from the McKowen Farm (5.08 plants per pot) was significantly (1% level of probability) less than the number in all other soils (7.25-7.83) even though the number of seeds planted (8 per pot)

TABLE 1. *Relation of farm, soil type, rainfall, and year to yield of corn grain on high yielding farms, 1967-1972.*

Farm	Soil type	Yield in Bushels per Acre 1967	1968	1969	1970	1971	1972	Mean	Coefficient of variation %	t for standard error of mean difference
H. McKowen	Crosby silt loam, bu/A	95	146	145	115	152	133	131	16.8	2.53*
	Brookston silt loam, bu/A	153	153	170	163	198	138	162	12.7	
	Mean yield bu/A	124	150	157	139	175	136	147		
	Rainfall, July + Aug., inches	2.32	7.22	8.59	7.41	6.86	---			
W. Franklin	Crosby silt loam	118	141	169	142	203	146	153	19.2	0.39
	Ragsdale silty clay loam	151	160	175	142	168	152	158	7.7	
	Mean	135	150	172	142	186	149	156		
	Rainfall, July + Aug., inches	1.24	3.96	8.63	4.18	4.58	---			
L. Priebe	Reesville silt loam	116	124	143	153	176	149	144	14.9	0.55
	Ragsdale silty clay loam	153	119	158	166	155	148	150	10.8	
	Mean	135	122	150	160	166	148	147		
	Rainfall, July + Aug., inches	9.19	7.01	8.80	6.52	9.47	5.94			
J. Bosstick	Iva silt loam	188	136	167	161	153	143	158	11.8	0.48
	Ragsdale silt loam	164	147	169	170	165	155	162	5.5	
	Mean	176	142	168	165	159	149	160		
	Rainfall, July + Aug., inches	5.75	5.46	7.67	3.90	7.47	---			
E. Neyhouse	Reesville silt loam	166	161	170	153	120	---[1]	154	13.0	0.42
	Zipp silt loam	190	146	180	156	130	---[1]	160	15.4	
	Mean	178	154	175	155	125	---	157		
	Rainfall, July + Aug., inches	13.41	9.00	17.99	5.18	18.90	---			
	Mean, all soils, bu/A	149	143	165	152	162	146	153		

* Significant at the 5% level

[1] Missing value figures for analysis of variance: Reesville = 146, Zipp = 152

was the same (Table 2). The reason appeared to be that water applied had not reached the kernels in sufficient amount in this Crosby soil because of surface sealing. There was no meaningful difference among the remaining seven soils, one of which was also a Crosby silt loam. Previously reported field studies of Stivers (8) pointed out that corn stands on high ground or swell soils were usually lower than those on adjacent low ground or swale soils. In these pot studies the same relationships between corn stands appeared to be true on Crosby and Brookston soils from the McKowen Farm.

TABLE 2. *Relation of corn plant growth in pots to farm, soil type, and fertilizer treatment.*

Farm and Soils or lbs/A of N-P-K	No. plant[1] per pot 6-18-73 Avg.	Dry wt.[1] tops per pot g	Max. height[1] per pot cm	Avg. color[1] per pot
H. McKowen, Crosby silt loam	5.08	Not Rep.[2]	Not Rep.[2]	Not Rep.[2]
H. McKowen, Brookston silt loam	7.83	4.54	52	2.67
W. Franklin, Crosby silt loam	7.67	3.58	46	2.17
W. Franklin, Ragsdale silty clay loam	7.75	4.54	51	2.50
L. Priebe, Reesville silt loam	7.25	4.54	53	2.75
L. Priebe, Ragsdale silty clay loam	7.83	5.45	53	2.75
J. Bosstick, Iva silt loam	7.50	3.92	49	2.42
J. Bosstick, Ragsdale silt loam	7.25	4.49	51	2.33
Least Significant Difference 5% level	0.84	.70	4	Not Sig.
Least Significant Difference 1% level	1.20	1.00	6	Not Sig.
0—0—0	6.92	3.01	44	2.19
0—87—167	7.46	3.34	46	2.24
200—87—167	7.33	5.03	54	2.71
400—87—167	7.38	6.37	58	2.90
Least Significant Difference 5% level	Not Sig.	0.52	3	0.41
Least Significant Difference 1% level	Not Sig.	0.69	4	0.54

[1] Figures are from three replications. Color: 1 = yellow, 5 = dark green.

[2] Not Rep. = Not reported because data available are partially the result of replanting.

Among the seven soils having approximately equal plant populations dry weights of corn plants were significantly (1% level of probability) different from each other (Table 2). As with grain yields, dry weights from the swale soils tended to be greater than those from swell soils taken from the same farm. Dry weights of those pots treated with N were significantly (1% level) higher as rates of N increased. Maximum heights of corn plants tended to show the same relationships to soils and fertilizer treatments that dry weights had (Table 2). The amount of green color in the corn in each treatment was greater as rates of N increased.

Data of High Yielding Fields and Statistical Reporting Service Compared

It took 2 years of gathering objective yield data of the Statistical Reporting Service (SRS) to get the comparisons given in Table 3.

The average corn yield of the SRS data given in Table 3 was 127 bu/acre (7,965 kg/ha), while that for high yielding (HY) farms was 145 bu/acre (9,094 kg/ha). In two of the three soils series compared in Table 3 the means of the SRS data were lower and their standard errors of the mean were higher than those of the HY data. In the third comparison the reverse was true.

Since as many as 339 or 559 corn grain yields (Table 3) from SRS data may be required to obtain an estimate of the mean yield of a soil series to within a range of plus or minus 5 bu/acre (314 kg/ha), it is obvious that SRS data are sometimes extremely variable.

TABLE 3. *Comparison of corn yield data from two sources, 1971 and 1972.*

Soils	Data[1] source	Yields in Bushels per Acre individual trials					Mean	Standard error of the mean	No.[2] of yields required L=X±5
		1972							
Brookston sil or sicl	SRS	153	154	135	152	150	149	± 3.51	19
Brookston sil	High yield	127	142	127	157	136	138	± 5.59	48
		1971-1972							
Crosby sil	SRS	99	53	102	144	---	100	±18.59	559
Crosby sil	High yield	140	159	136	134	---	142	± 5.72	53
		1971-1972							
Reesville sil	SRS	160	143	106	100	---	127	±14.47	339
Reesville sil	High yield	176	147	161	144	---	157	± 7.34	87

[1] SRS = Statistical Reporting Service data.

High yield = Individual subsample yields from McKowen (Brookston silt loam and Crosby silt loam) and Priebe (Reesville silt loam) farms.

[2] Probability of 95:5. L = limit; X = mean obtained in bu/A.

Application of Results

This report indicates that continuing the time consuming work of obtaining SRS crop yields and finding the soil types for these fields may be of questionable value for evaluating crop yields of important soil types in Indiana. Variation in yields on the same soil type may be very great, this requiring a very large number of yields to get a good estimate of the mean yield of a soil type.

From the pot experiment reported it can be inferred that eliminating the weather variable from comparing soil type productivity is quite desirable and perhaps within the realm of possibility. Moving soils by horizons to a common location and placing them on a common subsoil base could drastically improve the testing procedure for comparing soil type productivity, it is believed.

Summary and Conclusions

1) In the 6 years and seven different soil types sampled on high yielding farms, corn yields of the swell soils tended to be lower and more variable than those of the swale soils. Results of a

pot experiment with corn on six of the seven different soil types supported the field research findings.

2) Objective yield data of the SRS were compared with individual subsample yields of corn from selected high yielding farms by soil type. In these 13 comparisons the corn yields of the SRS soil series tended to be lower and more variable than those from the same soil series on high yielding farms.

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